Temporary Seeding

Practice Description

The establishment of fast-growing annual vegetation to provide economical erosion control for up to 12 months and reduce the amount of sediment moving off the site. Annual plants which sprout rapidly and survive for only one growing season are suitable for establishing temporary vegetative cover.

This practice applies where short-lived vegetation can be established before final grading or in a season not suitable for permanent seeding. It helps prevent costly maintenance operations on other erosion control systems such as sediment basin clean-out. Temporary or permanent seeding is necessary to protect earthen structures such as dikes, diversions, and the banks and dams of sediment basins.

N. Klopfenstein, NRCS. St. Charles Co.

Temporary vegetation is a relatively inexpensive way to stabilize construction sites in a hurry. As grass grows, the roots hold soil in place and the plant protects the soil surface from raindrop impacts.

Recommended Minimum Requirements

Prior to start of construction, plant materials, seeding rates and times should be specified by a qualified professional. Plans and specifications should be referred to by field personnel throughout the construction process. To ensure emergence, vigorous growth of seedlings and contin

ued plant growth, prepare seedbed, add lime and fertilizer according to soil tests, mulch all but the most ideal sites and follow seeding dates.

- **Seedbed Preparation:** Loosen soil to depth of 3 inches for broadcast seeding or drilling. If compacted, loosen soils for no till drilling. Avoid excessively wet conditions.
- **Amendments:** Fertilizer and lime (if soil pH is less than 5.3) incorporated 3 to 6 inches into the soil. See Table 5.1.
- **Seed Quality:** Certified seed, tested within the past 9 months
- **Plants:** Recommended temporary erosion control plant species. Rate of application and seeding dates are listed in Tables 5.2 and 5.3.
- **Mulch:** 75% of the ground surface should be covered with approved mulching materials (See *Mulching*). Mulching is critical for the less than ideal situations found on development sites.
- **General:** Inspect seeded areas 2 to 4 weeks after seeding for establishment, erosion control and weed control. Repair and reseed as necessary.
- **Reseed:** After 1 year if site is not in permanent vegetation

Installation

Successful vegetative establishment is directly dependent on the nutrients in the soil. For optimum results, take soil samples from the top 6 inches in each area to be seeded. Submit samples to a soil testing laboratory for liming and fertilizer amendment recommendations.

Seedbed Preparation

Seedbed preparation is essential for the seed to germinate and grow.

For broadcast seeding and drilling, loosen the soil to a depth of approximately 3 inches.

For no-till drilling, the soil surface does not need to be loosened unless the site has surface compaction.

Use a disk, ripper, chisel, harrow or other acceptable tillage equipment to loosen compacted, hard or crusted soil surfaces.

Avoid preparing the seedbed under excessively wet conditions.

Liming

Acid soils with an extremely low pH can prevent seeding success. Most of the recommended temporary vegetation is tolerant of low pH soils and will establish on all but the lowest pH soils.

If soil pH in the region is known to be extremely low, **conduct a soil pH test** to determine if limestone is necessary for temporary seeding.

Amend soils with lime according to information in Table 5.1.

Soils with a pH above 7.0 should not be limed.

Table 5.1 Liming Requirements for Temporary Sites

pH Test	Plant Response	Recommended Application of Agricultural Limestone
below 6.0	poor growth	lime according to soil test
6.0 - 6.5	adequate growth	no lime recommended
greater than 6.5	greater than 6.5	no lime recommended

Fertilizer

Subsoil will most likely be deficient in nutrients required for growth. A **soil test will provide the best guide** for the amount and types of fertilizer to apply for optimum plant growth.

A general recommendation is to broadcast 90 lbs. of **actual** N-P-K per acre for areas receiving more than 30 inches of precipitation and 50 lbs. of N-P-K per acre in areas receiving less than 30 inches of precipitation.*

For best results incorporate the fertilizer into the top 3 to 6 inches before seeding.

* For example, to compute the bulk pounds of product to use

$$\frac{\text{Actual \# Needed}}{\text{\% Available}} \text{ or } \frac{90\#}{28\%} = 321\# \text{ Bulk}$$

Seeding

Apply seed evenly with a broadcast seeder, drill, cultipacker seeder or hydroseeder. Plant small grains no more than 1 1/2 inches deep. Plant grasses and legumes no more than 1/2 inch deep.

Prior to mulching, harrow, rake or drag a chain to lightly incorporate broadcast seed and enhance germination. Cover broadcast or drilled seed with mulch (See *Mulching*). On bare soils, firm lightly with a roller or a cultipacker.

Table 5.2 Temporary Seeding Plant Materials and Minimum Seeding Rate *

Species	Seeding Rate		Plant Characteristics
	lbs. per Acre	lbs. per 1,000 ft.^{2}	
Oats	80 lbs	2 lbs	not cold tolerant, height up to 2 feet
Cereals: Rye/Wheat	90 / 120	2.0 / 2.5	cold tolerant, height up to 3 feet, low pH tolerant
Millets, Sudangrass	45 / 60	1.0 / 1.25	warm season annual, aggressive growth, height up to 5 feet
Annual Ryegrass	75	2	may be added to mix, not heat tolerant, height up to 16 inches
Annual Lespedeza ** plus Tall Fescue	15 plus 45	0.5 plus 1.0	warm season annual legume, makes own nitrogen, tolerates low pH

* In areas receiving less than 30 inches of precipitation, use 75 percent of these rates.

** If there is any possibility that the seeding will be required to control erosion for more than one year, then consider the addition of fescue or another permanent species as part of a mixture when seeding.

Planting Dates

Plant according to the design plan. In absence of a plan, choose a recommended temporary species or mixture appropriate for the season from Tables 5.2 and 5.3.

Plant during optimum seeding dates if at all possible. Use mulch if planting during acceptable seeding dates. Roll and cultipack broadcast seed for good soil-to-seed contact.

Use high quality seed. For best results use certified seed. When using uncertified seed, use the highest recommended seeding rate.

Table 5.3 Seeding Dates for Temporary Seedings

Species	Seeding Dates Optimum & Acceptable											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Oats												
Cereals: Rye/Wheat												
Millets, Sudangrass												
Annual Ryegrass												
Annual Lespedeza plus Tall Fescue [1]												

1 If site may not be developed within one year, consider permanent species listed in Table 5.8.

Table Key:

Optimum Seeding Dates	
Acceptable Seeding Dates	

Mulching Mulching is recommended to conserve moisture and reduce erosion.

Evenly cover 75% of the ground surface with mulch material specified in the design plan. Tack or tie down according to plan (See *Mulching*).

Construction Verification Check materials and installation for compliance with specifications.

Troubleshooting

Consult with a qualified design professional if the following occurs:

- Design specifications for seed variety, seeding dates or mulching cannot be met; substitutions may be required. Unapproved substitutions could lead to failure.

Maintenance

Check temporary seedings within 2 to 4 weeks of planting to see if stands are of adequate thickness (more than 30% of the ground surface covered). Stands should be uniform and dense for best results. Fertilize, reseed and mulch bare and sparse areas immediately to prevent erosion.

Mowing is not recommended for cereals seeded alone. Cereals seeded with a grass can be mowed when height is greater than 12 inches. However, to prevent damage to grasses, do not mow shorter than 4 inches.

Millets and sudangrass should be mowed before height is greater than 6 inches to allow regrowth and continued erosion protection.

Annual lespedeza and tall fescue may be mowed after height exceeds 8 inches. Do not mow shorter than 4 inches.

Replant temporary or permanent vegetation within 12 months as annual plants die off and no longer provide erosion control (see *Permanent Seeding*). Consider no-till planting where possible.

Common Problems

Inadequate seedbed preparation; causes poor seedling emergence and growth—repair gullies, prepare seedbed, fertilize, lime (if necessary), mulch and reseed.

Unsuitable choice of plant materials; resulting in poor germination or inadequate stand (less than 30% of the ground surface covered)—choose plant materials appropriate for season, prepare seedbed and replant.

Inadequate mulching; resulting in poor or spotty stands—cover area evenly and tack or tie down mulch properly, especially on slopes, ridges and in channels.

Lack of nitrogen; causes poor plant vigor, yellow color and short height—add 50 lbs. of nitrogen fertilizer per acre. Do not apply over the top of existing plants from June 1 to August 15 or on frozen ground.

Dying plants; usually caused by soil compaction that limits root growth and water availability to plants—loosen soil if reseeding is necessary or before seeding permanent vegetation.

Temporary Seeding _____

Permanent Seeding

Practice Description

The establishment of perennial vegetation on disturbed areas for periods longer than 12 months. Permanent vegetation provides economical long-term erosion control and helps prevent sediment from leaving the site. This practice is used when vegetation is desired to permanently stabilize the soil. It is necessary to protect earthen structures such as dikes, channels and embankments. Particular care is required to establish a good, thick cover of permanent grass.

Permanent vegetation can be used to stabilize many structures, such as this grassed waterway, ensuring that runoff is relatively sediment-free.

N. Klopfenstein, NRCS. St. Charles

Recommended Minimum Requirements

Prior to start of construction, plant materials, seeding rates and times should be specified by a qualified professional. Plans and specifications should be referred to by field personnel throughout the construction process. To ensure germination and growth, prepare seedbed, add lime and fertilizer according to soil tests, mulch all but the most ideal sites and follow seeding dates.

- **Seedbed Preparation:** For broadcast seeding or drilling, loosen soil to depth of 3 inches. For no till drilling, loosen soil if it's compacted. Avoid excessively wet conditions.

- **Soil Amendments:** Fertilizer and lime (if soil pH is less than 6.0) incorporated 3 to 6 inches into the soil
- **Seed Quality:** Certified seed, tested within the past 9 months
- **Planting Dates:** Appropriate for region and species (See Table 5.4)
- **Plants:** Recommended erosion control plants (grass or grass/legume mixtures) as shown in Tables 5.5 and 5.6. Rate of application and seeding dates are shown in Tables 5.4, 5.7 and 5.8.
- **Mulch:** 75% of the ground surface covered with approved material (See *Mulching*)
- **Inspection:** Inspect seeded areas 4 to 6 weeks after seeding. Repair and reseed as necessary.

Installation

During final grading, take soil samples from the top 6 inches in each area to be seeded. Submit sample to a soil testing laboratory for liming and fertilizer recommendations.

Seedbed Preparation

Seedbed preparation is essential for the seed to germinate and grow.

For broadcast seeding and drilling, loosen the soil to a depth of approximately 3 inches.

For no-till drilling, the soil surface does not need to be loosened unless the site has surface compaction.

Loosen compacted, hard or crusted soil surfaces with a disk, ripper, chisel, harrow or other tillage equipment.

Avoid preparing the seedbed under excessively wet conditions.

Liming

Follow the design plan. Apply ground agricultural limestone unless a **soil test** shows a pH of 6.5 or greater.

If a soil test or plan is not available, use 2 tons of ground agricultural lime.

Incorporate lime into the top 3 to 6 inches of soil.

Fertilizer

For establishment and long-term growth, apply a complete fertilizer at rates recommended by **soil tests** or as specified in the design plan. In the absence of soil tests, use the following as a guide:

Cool Season Grasses: Apply 90–90–90 N–P–K if rainfall exceeds 30 inches per year. Apply 50–50–50 N–P–K if rainfall is less than 30 inches per year.

Cool Season Grass/Legume Mixtures: Apply 60–90–90 N–P–K.

Warm Season Grasses: Apply 0–60–30 N–P–K.

Cool/Warm Season Grass Mixtures: Apply 30–60–30 N–P–K.

Note: Fertilizer can be blended to meet exact fertilizer recommendations. Take soil test recommendations to local fertilizer dealer for bulk fertilizer blends. This may be more economical than bagged fertilizer.

Incorporate lime and fertilizer to a depth of 3 to 6 inches by disking or chiseling on slopes of up to 3:1.

Grade soil to a smooth firm surface to enhance rooting of seedlings and reduce rill erosion.

Plant Selection

If not specified in the design plan, choose a suitable species of grass or a grass/legume mixture from Tables 5.5 and 5.6 appropriate for the season (Table 5.4). Consider site conditions including soils, plant characteristics, region of the state and desired level of maintenance. The species shown are adapted for lawns and erosion control. If there are

questions on species selection and how they may be adapted in wildlife habitat or wetland applications, contact your local NRCS or Extension office.

Developing a Mixture

A pure stand of grass provides the best erosion control. The advantage of a grass/legume mix is that the legume provides nitrogen to the grass and often grows during hotter and drier months when the grass is dormant. Usually one grass and one or two legumes is sufficient in a mixture. More grasses can be mixed together, but may be of little use. Refer to Tables 5.5 and 5.6 for information about each grass and legume to determine the correct species for your site.

Nurse Crops

Nurse crops such as wheat, rye and oats are sometimes used in a seeding mixture. These winter annuals can reduce weeds, control erosion and provide winter protection to young seedlings.

Plant nurse crops about 1 inch deep. Most permanent grasses and legumes are sown 1/4 inch deep. Permanent seedings should not be planted deeper than 1/4 to 1/2 inch.

Aesthetic Plantings

A wide variety of native forbs and grasses are available that add diversity and beauty to permanent plantings (i.e., switchgrass as an accent). Contact your local NRCS office for species selection and seeding rates.

Planting Dates

If seeding dates are not specified in the design plan, use the seeding calendar shown in Table 5.4.

Plant during optimum seeding dates if at all possible. Use mulch if planting during acceptable or dormant seeding dates. For dormant seeding dates, broadcast seed and immediately roll and cultipack for good soil-to-seed contact.

If unable to seed according to schedule, use temporary seeding until preferred date for permanent seeding.

Seeding Rates

If seeding rates are not specified in the design plan, use rates in Table 5.7 for grasses alone. Use rates in Table 5.8 for a grass/legume mixture. These rates are based on the poor growing conditions that typically exist on a development site, a need for dense growth and high germination rates.

Table 5.4 Planting Dates
Optimum and Acceptable* Planting Dates

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Turf Fescue		*	*		*			*	*	*		
Tall Fescue		*	*		*			*	*	*		
Kentucky Bluegrass		*	*		*			*	*	*		
Perennial Ryegrass		*	*		*			*	*	*		
Redtop		*	*		*			*	*	*		
Reed Canary		*	*		*			*	*	*		
Bermuda-Common						*	*					
Bermuda - Hybrid						*	*					
Buffalo Grass [1]			*	*		*	*					
Zoysia [2]						*	*					
Birdsfoot Trefoil	*	*	*									
Crownvetch	*	*	*									
Common Lespedeza												
Red Clover	*	*	*					*				
White Clover	*	*	*									
Soricoa Lespedeza [3]	*	*	*					*				
Wheat/Rye [4]	*							*			*	
Oats [4,5]		*						*				
Warm Season Grasses [6]	*	*	*			*						*

Table Key

Optimum Seeding Date	
*with mulch cover - Acceptable/Dormant Seeding Date	*

1 Can also be sprigged.
2 Usually sprigged. Space plugs every 6, 8 or 12 inches; with 4,000, 2,250 or 1,000 sprigs/1000 ft^2 respectively.
3 Check with your local Noxious Weed Department before planting.
4 Nurse crop only.
5 Provides a quick temporary cover or nurse crop even if planted in the fall.
6 Mulch areas.

Table 5.5 Plant Characteristics

Species		Kansas Adaptation	Missouri Adaptation	Maintenance	Fertility Needs	Establishment Ease
				L - M - H [1]	L - M - H [1]	P - M - G [2]
Cool Season Grasses	Perennial ryegrass	E, C, W *	N, S	L	M	M
	Canada wildrye	E, C, W	N, S	M	L	G
	Tall fescue	E, C, W *	N, S	M	L - H	G
	Crested wheatgrass	E, C, W	N	M	L	M - G
	Kentucky bluegrass	E, C, W *	N, S	H	M - H [3]	M - G
	Bromegrass	E, C, W *	N, S	M	M - H [3]	M - G
	Redtop	S½ E	N, S	L	L	M
	Reed canary [4]	E, C, W *	N, S	H	L - M [5]	P
Warm Season Grasses	Common Bermuda	S½ E, C	S	L	L - M	M
	Hybrid Bermuda	S½ E, C	-	L	L - M	M
	Buffalograss [6]	E, C, W	N, S	L	L	M
	Blue grama	E, C, W	N, S	L	L	M
	Zoysia [7]	S½ E,C	-	M	M - H	M
	Sideoats grama	E, C, W	N, S	M	L	G
	Little bluestem	E, C, W	N, S	M	L	M
	Big bluestem	E, C, W	N, S	M	L	M
	Indiangrass	E, C, W	N, S	M	L	M
	Switchgrass	E,C,W	N, S	M	L	M
Legumes [8]	Birdsfoot trefoil	E, C *, W *	N, S	L	M	P - M
	Crownvetch	E, C, W	N, S	M	M	P - M
	Annual lespedeza [9]	E, C, W *	N, S	M	M	P - M
	Red clover	E, C *, W *	N, S	M	M	G
	White clover	E, C *, W *	N, S	L	L	M - G
	Alfalfa	E, C *, W *	N, S	M	M	P
Companion Crops/Cereal Grains	Wheat				M	M
	Rye (cereal)				M	M
	Oats				M	M

*** Adaptation limited to areas which receive additional moisture enhancement by irrigation, subirrigation or overland flow.**

1 L = low, M = moderate, H = high
2 P = poor, M = moderate, G = good
3 Will be high maintenance in lawn-type or low rainfall (<30") settings.
4 Adapted to shorelines, wet or frequently flooded areas.
5 Responds well to fertilizer, but doesn't necessarily require it.
6 Usually seeded, but can be sprigged.
7 Usually sprigged, plugged or sodded.
8 Legumes alone will not provide adequate erosion protection: use with a grass in a mixture.
9 Will reseed each year if not mowed until after seed shatter in September.

Table 5.6 Species Tolerance for Environmental Conditions

Species		Tolerance				
		Shade	Drought	Flooding	Traffic	Soil Wetness
		L - M - H				P - M - G
Cool Season Grasses	Perennial ryegrass	L	L	M	M	M
	Canada wildrye	M	M	L	M	P
	Tall fescue	M	M	M	M	P
	Crested wheatgrass	L	H	M	M	G
	Kentucky bluegrass	L	L	M	H	G
	Bromegrass	L	M	L	H	M
	Redtop	L	L	M	H	G
	Reed canary	L	M	H	H	G
Warm Season Grasses	Common Bermuda	L	H	H	H	M
	Hybrid Bermuda	L	H	H	H	M
	Buffalograss	L	H	H	H	G
	Blue grama	L	H	L	M	P
	Zoysia	L	H	M	H	P
	Sideoats grama	L	H	M	H	M
	Little bluestem	L	H	L	L	P
	Big bluestem	L	H	M	L	M
	Indiangrass	L	M	L	M	P
	Switchgrass	L	M	M	M	G
Legumes[1]	Birdsfoot trefoil	L	H	L	M	G
	Crownvetch	L	H	M	H	M
	Annual lespedeza	L	L	M	L	M
	Red clover	L	L	L	M	P
	White clover	L	L	L	H	M
	Alfalfa	L	L	L	L	P

Key: P = Poor, L = Low, M = Moderate, G = Good, H = High

1 **Legumes alone** will not provide adequate erosion protection: use with a grass in a mixture.

Table 5.7 Seeding Rates

Species		Kansas: Full Seeding Rate[1] lbs./acre (PLS)[2]	Missouri: Full Seeding Rate[1] lbs./acre (PLS)[2]
Cool Season Grasses	Perennial rye	80	80
	Canada wildrye	21	24
	Tall fescue	80	80
	Crested wheatgrass	20	16
	Kentucky bluegrass	50	50
	Bromegrass	100	100
	Redtop	8	8
	Reed canary	40	40
Warm Season Grasses	Common Bermuda	2	4
	Hybrid Bermuda	20 bu./acre	–
	Buffalograss	8 (grain)	8 (grain)
	Blue grama	3	6
	Zoysia	20 bu./acre	–
	Sideoats grama	15	15
	Little bluestem	9	13
	Big bluestem	17	16
	Indiangrass	12.5	16
	Switchgrass	8	9
Legumes[3]	Birdsfoot trefoil	5	10
	Crownvetch	18	16
	Annual lespedeza	14	16
	Red clover	8	12
	White clover	3	4
	Alfalfa	9	9
Companion Crops	Wheat	1 bu./acre	1 bu./acre
	Rye (cereal)	1 bu./acre	1 bu./acre
	Oats	1½ bu./acre	1½ bu./acre

1 **Note:** Rates based on typical construction site conditions where seedbed is normally less than ideal. Planned future use or specific site conditions may dictate an increase or a decrease in rates. Contact your local NRCS office or consulting agronomist for specific seeding rates within your county.

2 **PLS or Pure Live Seed = the amount of seed guaranteed to grow.** (See note on page 51.)

3 **Legumes alone** will not provide adequate erosion protection: use with a grass in a mixture.

Table 5.8. Example Seeding Mixtures for Critical Area Seedings

Grass-Legume Mixture	Seeding Rate (PLS) *	
	lbs. / 1000 ft ^{2} ***	lbs. / acre
Reed Canarygrass / White Clover	5 + 0.1	40 + 1
Reed Canarygrass / Red Clover	5 + ¼	40 + 2
Tall Fescue** / Birdsfoot Trefoil	10 + ¼	80 + 2
Tall Fescue** / White Clover	10 + 0.1	80 + 1
Tall Fescue** / Lespedeza	10 + ½	80 + 4
Tall Fescue** / Lespedeza / White Clover	10 + ½ + 0.1	80 + 4 + 1
Tall Fescue** / Red Clover	10 + ¼	80 + 2
Tall Fescue** / Red Clover / White Clover	10 + ¼ + 0.1	80 + 2 + 1
Kentucky Bluegrass / White Clover	3 + 0.1	25 + 1
Kentucky Bluegrass / Red Clover	3 + ¼	25 + 2
Kentucky Bluegrass / Birdsfoot Trefoil	3 + ¼	25 + 2
Kentucky Bluegrass / Lespedeza	3 + ½	25 + 4
Perennial Ryegrass / Red Clover	8 + 1	70 + 10
Perennial Ryegrass / Birdsfoot Trefoil	8 + ½	70 + 5
Perennial Ryegrass / Lespedeza	8 + 3	70 + 25
Big Bluestem / Indiangrass / Switchgrass / Sideoats grama / Western Wheatgrass	—	3.4 + 2.5 + 2 + 3 + 4
Wheat/Rye (as nursery crop)	1.5	60
Oats (as nursery crop)	0.75	30

*** PLS or Pure Live Seed = the amount of seed guaranteed to grow.** To calculate amount of bulk seed needed: Read seed tag and multiply % purity X % germination = % PLS; then divide lbs of PLS recommended by % PLS. Example: 30 lbs of Reed canary is needed to seed a 1 acre waterway; 90% pure X 90% germination = 81% PLS; 30 lbs PLS / .81 = 37 lbs. bulk seed needed.

**** Turf fescue may be substituted for fescue at the same rates.**

*****Note:** Use lbs. / 1000 ft.^{2} rate to establish dense vegetation for lawns.

Seeding Rates *(continued)*

For best results use certified seed. When using uncertified seed, use the highest recommended seeding rate. Higher seeding rates will not substitute for good seedbed preparation.

Seeding

Apply seed uniformly using a cyclone seeder, drop-type spreader, drill, cultipacker seeder or hydroseeder.

When using a drill seeder, plant rye or other grains about 1 inch deep; plant grasses and legumes no more than 1/2 inch. Calibrate equipment in the field.

Cover seed by raking, or dragging a chain, brush or mat. Then firm the soil lightly with a roller. Seed can also be covered with hydromulched wood fiber and tackifier.

Legumes

Legumes require inoculation with nitrogen-fixing bacteria to ensure good growth. Purchase inoculum from seed dealer and mix with seed prior to planting.

Mulching

Mulching is recommended to conserve moisture and reduce erosion.

Cover at least 75% of the area with approved mulch materials. Crimp, tack or tie down mulch with netting. Mulching is extremely important for successful seeding (See *Mulching*).

Construction Verification

Check materials and installation for compliance with specifications.

Troubleshooting

Consult with design professional if the following occurs:

- Design specifications for seed variety, seeding dates or mulching cannot be met; substitutions may be required. Unapproved substitutions could lead to failure.

Maintenance Expect emergence of grasses within 4 to 28 days and legumes 5 to 28 days after seeding, with legumes following grasses.

Check permanent seedings within 4 to 6 weeks after planting. Look for:

- Vigorous seedlings;
- Uniform density with at least 30% of the ground surface covered;
- Uniformity with nurse plants, legumes and grasses well intermixed; and
- Green, not yellow, leaves. Perennials should remain green throughout the summer, at least at the plant bases.

Reseeding Inspect seedings for erosion or die out for at least a year. To repair bare and sparse areas, fill gullies, refertilize, reseed and mulch. Consider no-till planting where possible.

If stand is inadequate or plant cover is patchy, identify the cause of failure and take corrective action: choice of plant materials, lime and fertilizer quantities, poor seedbed preparation or weather. If vegetation fails to grow, have the soil tested to determine whether pH is in the correct range or nutrient deficiency is a problem.

Depending on stand conditions, repair with complete seedbed preparation, then overseed or reseed.

If it's the wrong time of year to plant desired species, overseed with cereal grain or millets to thicken the stand until timing is right to plant perennials or use temporary seeding.

Fertilization Satisfactory establishment may require refertilizing the stand in the second growing season.

- Do not fertilize cool season grasses in late May through July.
- Grass that looks yellow may be nitrogen deficient. An application of 50 lbs of N-P-K per acre in early spring will help cool season grasses compete against weeds or grow more successfully.

Remember to convert **actual** pounds of nutrient needed when determining how many pounds of commercial fertilizer to buy.

- Do not use nitrogen fertilizer if stand contains more than 20% legumes.

Mowing

Consider mowing after plants reach a height of 6 to 8 inches.

Mow grasses tall, at least 3 inches in height and minimize compaction during mowing process.

Monitor the late winter and early spring growth of nurse crops to be sure that they do not smother the permanent seeding. Mowing in April may reduce the competitiveness of the nurse crop and open the canopy to allow more sunlight to permanent seedlings that are beginning to grow.

Vegetation on structural practices such as embankments and grass-lined channels need to be mowed only to prevent woody plants from invading.

Common Problems

Inadequate seedbed preparation; results in poor stand—prepare well-tilled, limed and fertilized seedbed and reseed.

Unsuitable choice of plant materials such as seeding Bermuda grass in the north or in the fall; results in stand failure—select an appropriate species based on plant characteristics in Tables 5.5 and 5.6 and time of seeding (Table 5.4).

Nurse crop rate too high in mixture; results in perennial being outcompeted—limit rates to those shown in Table 5.8; eliminate old nurse crop, prepare seedbed and reseed.

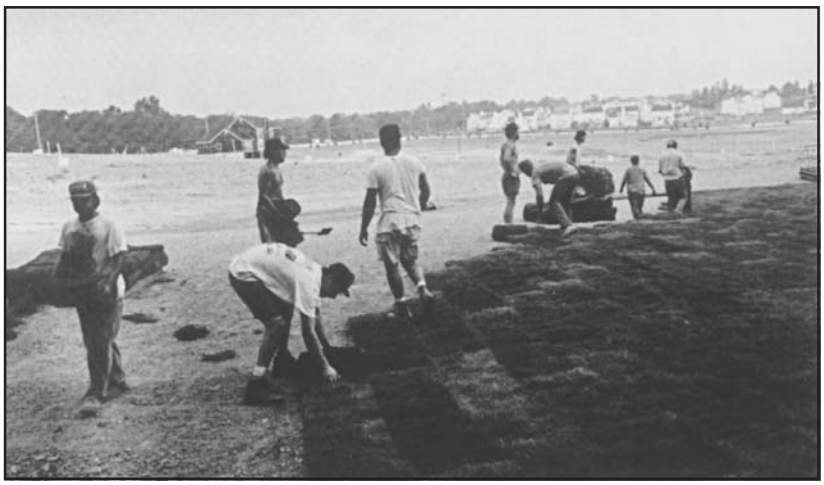
Seeding at the wrong time of the year; resulting in inadequate stand—consult Table 5.4 and reseed. If timing is not right, use temporary seeding to stabilize soil until preferred seeding dates.

Inadequate mulching; results in inadequate stand, bare spots or eroded areas—prepare seedbed, reseed, cover seed evenly and tack or tie down mulch, especially on slopes, ridges and in channels (see *Mulching*).

Sodding

Practice Description

The use of a vegetative cover to provide immediate erosion control in disturbed areas. Sodding is well suited for stabilizing erodible areas such as grass-lined channels, stormwater detention basins, diversions, swales, slopes and filter strips.



N. Klopfenstein, NRCS. St. Charles Co.

To prevent roots from drying out, moisten soil surface and butt sod joints tightly against each other.

Recommended Minimum Requirements

Prior to start of installation, plant materials and amendments should be specified by a qualified professional. Plans and specifications should be referred to by field personnel throughout the installation process.

- **Plant Selection**: High quality, healthy, moist, fresh sod. Select a variety that is well-adapted to the region, intended use and desired level of maintenance. (See Table 5.9)
- **Soil Amendments:** Fertilizer and lime (if soil pH is less than 6.0) incorporated to a depth of 3 to 6 inches into the soil
- **Soil Surface:** Clear of clods, rocks, etc.; smooth and firm; not compacted clay or pesticide-treated soil
- **Irrigation:** Required to ensure rooting
- **Timing:** Anytime of the year, except when the soil is frozen

Installation

Soil supplied nutrients are critical to sod establishment and continued plant growth. **Test soil for nutrients and pH.** Soil testing can be done at University Extension offices and private labs.

Site Preparation

Apply amendments **according to soil test recommendations.** In the absence of a soil analysis, apply fertilizer amendments at the following maximum rates:

Fertilizer: 90-90-90 N-P-K per acre or consult sod sales person

Apply ground agricultural limestone unless a **soil test** shows a pH of 6.0 or greater. If soil test recommendations are not available and soil pH is less than 6.0, use:

Ground agricultural limestone: 20 lbs ENM or ECC* /1000 ft^2 or 800 lbs ENM or ECC* /acre (approx. 2 tons/acre)

Incorporate amendments to depth of 4 to 6 inches with a disk or chisel plow.

Rake or harrow to achieve a smooth, final grade on which to lay the sod. Surface should be loose, and free of plants, trash and other debris.

Table 5.9 Sod Species Adaptation to Regions of the State

Species	Kansas	Missouri
Kentucky Bluegrass	East and Central	Statewide
Turf Fescue	East and Central	Statewide
Bermuda		
common	South half, east, central	Southern half
improved	South half, east, central	Southern third
Zoysia	South half, east, central	Southern half
Buffalograss	Statewide	Statewide

Laying Sod

Sod should not be laid on soil surfaces that are frozen.

* Missouri state agricultural lime laws require that ag lime be sold as units of Equivalent Neutralizing Material (ENM)/ton. For example, soil test requires 800 lbs ENM and lime producer's material tests at 400 lbs ENM. 800 ÷ 400 = 2 tons to be applied. See MU Guide #9107 for details. In Kansas, ECC (Effective Calcium Carbonate) = ENM. (See *Glossary* for definition.)

During high temperatures, moisten the soil immediately prior to laying sod. This cools the soil and reduces root burning and dieback.

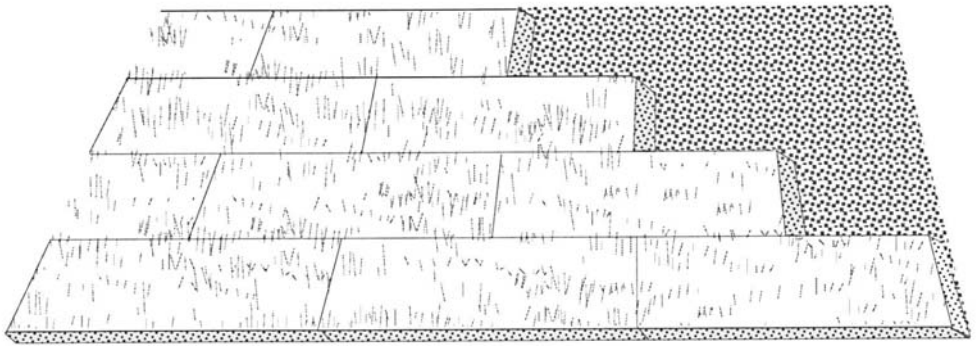
Lay the first row of sod in a straight line with subsequent rows placed parallel to and butting tightly against each other. Stagger joints to create a brick-like pattern and promote more uniform growth and strength. Ensure that sod is not stretched or overlapped and that all joints are butted tight to prevent spaces which would cause drying of the roots. (See Figure 5.2).

On slopes 3:1 or steeper, or wherever erosion may be a problem, lay sod with staggered joints and secure by stapling or pegging. Install sod with the length perpendicular to the water flow (on the contour).

Immediately after laying the sod, roll or tamp it to provide firm contact between roots and soil, then irrigate sod deeply so that the underside of the sod pad and the soil 4 inches below the sod is thoroughly wet.

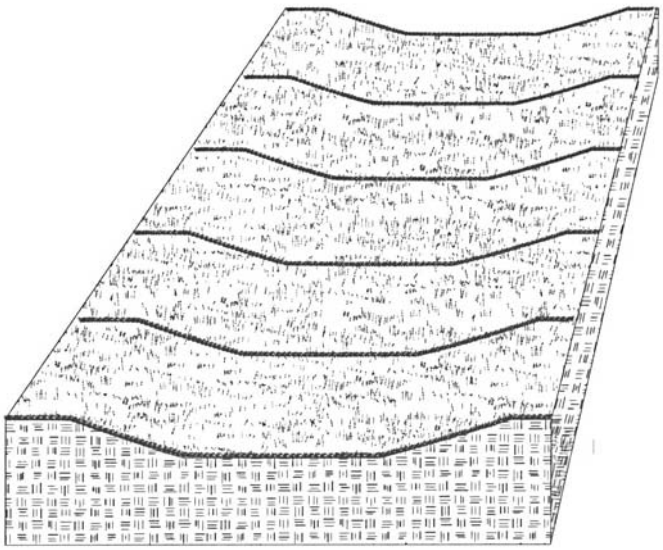
Until a good root system develops, water sod during dry periods as often as necessary to maintain moist soil to a depth of at least 4 inches.

Wait until the sod is firmly rooted before mowing for the first time, usually 2 to 3 weeks. Not more than 1/3 of the grass leaf should be removed at any one cutting.



Lay sod in a staggered pattern with strips butted tightly against each other.

Figure 5.2 Typical Installation of grass sod



Lay sod across the direction of flow. Use pegs or staples to fasten sod firmly at the corners and in the center.

Figure 5.3 Installation of Sod in Waterways

Sodded Waterways

Sod provides quicker protection than seeding and may reduce the risk of early washout unless fiber blankets are used.

When installing sod in waterways, use the type of sod specified in the channel design.

Lay sod strips perpendicular to the direction of water flow and stagger in a brick-like pattern. See Figure 5.3.

Staple firmly at the corners and middle of each strip. Jute or synthetic netting may be pegged over the sod for further protection against washout during establishment.

Construction Verification

Check materials and installation for compliance with specifications.

Troubleshooting

Consult with qualified design professional if any of the following occur:

- Variations in topography on site indicate the sodding materials will not function as intended; changes in plan may be needed.
- Design specifications for sod variety cannot be met or irrigation is not possible; substitution or seeding may be required. Unapproved substitutions could result in erosion or sodding failure.

Maintenance

Keep sod moist until it is fully rooted.

Mow to a height of 2 to 3 inches after sod is well-rooted, in 2 to 3 weeks. Do not remove more than 1/3 of the leaf blade in any mowing.

Permanent, fine turf areas require yearly fertilization. Fertilize warm-season grass in late spring to early summer; cool-season grass in late winter and again in early fall.

Common Problems

Sod laid on poorly prepared soil or unsuitable surface; grass dies because it is unable to root—remove dead sod, prepare surface and resod.

Sod not adequately irrigated after installation; may cause root dieback or grass does not root rapidly and is subject to drying out—irrigate sod and underlying soil to a depth of 4 inches and keep moist until roots are established.

Sod not anchored properly; may be loosened by runoff—replace damaged areas and anchor sod.

Slow growth due to lack of nitrogen; may cause yellowing of leaf blades—refertilize sod, but avoid fertilizing cool season grasses from late May through July.

Sodding

Mulching

Practice Description

The application of plant residues such as straw or other suitable materials to the soil surface. Mulch protects the soil surface from the erosive force of raindrop impact and reduces the velocity of overland flow. It helps seedlings germinate and grow by conserving moisture, protecting against temperature extremes and controlling weeds. Mulch also maintains the infiltration capacity of the soil.

Mulch can be applied to seeded areas to help establish plant cover. It can also be used in unseeded areas to protect against erosion over the winter or until final grading and shaping can be accomplished.

N. Klopfenstein, NRCS. St. Charles Co.

It takes about two tons per acre of straw mulch to cover at least 75 percent of the ground surface. To prevent erosion and provide the best microclimate for seed establishment, straw mulch should be physically anchored or tied down with a tackifier.

Recommended Minimum Requirements

Prior to start of construction, mulch requirements should be designed by a qualified professional. Plans and specifications should be referred to by field personnel throughout the construction process.

- **Material:** As specified in the approved site plan. If not specified, select from mulch materials listed in Table 5.10. The choice should be based upon soils, slope steepness and length, flow conditions and time of year (See Figure 5.4).

- **Coverage:** At least 75% of the soil surface
- **Anchoring:** Light materials such as hay and straw should be anchored mechanically, or with tackifiers or netting. Heavy material mulches such as wood chips will not require anchoring.

Installation

Site Preparation

Divert runoff water from areas above the site that will be mulched.

Remove stumps, roots and other debris from the construction area.

Grade area as needed to permit the use of equipment for seeding, mulching and maintenance. Shape area so that it is relatively smooth.

If the area will be seeded, follow seeding specifications in the design plan (See *Temporary* and *Permanent Seeding*) and apply mulch immediately after seeding.

Mulching

Spread straw or cereal grain mulch uniformly over the area with a power blower, hydroseeder or by hand. No more than 25% of the ground surface should be visible after spreading.

Apply at the rates shown in Table 5.10. Use higher rates for steep slopes, channels and other erosive areas.

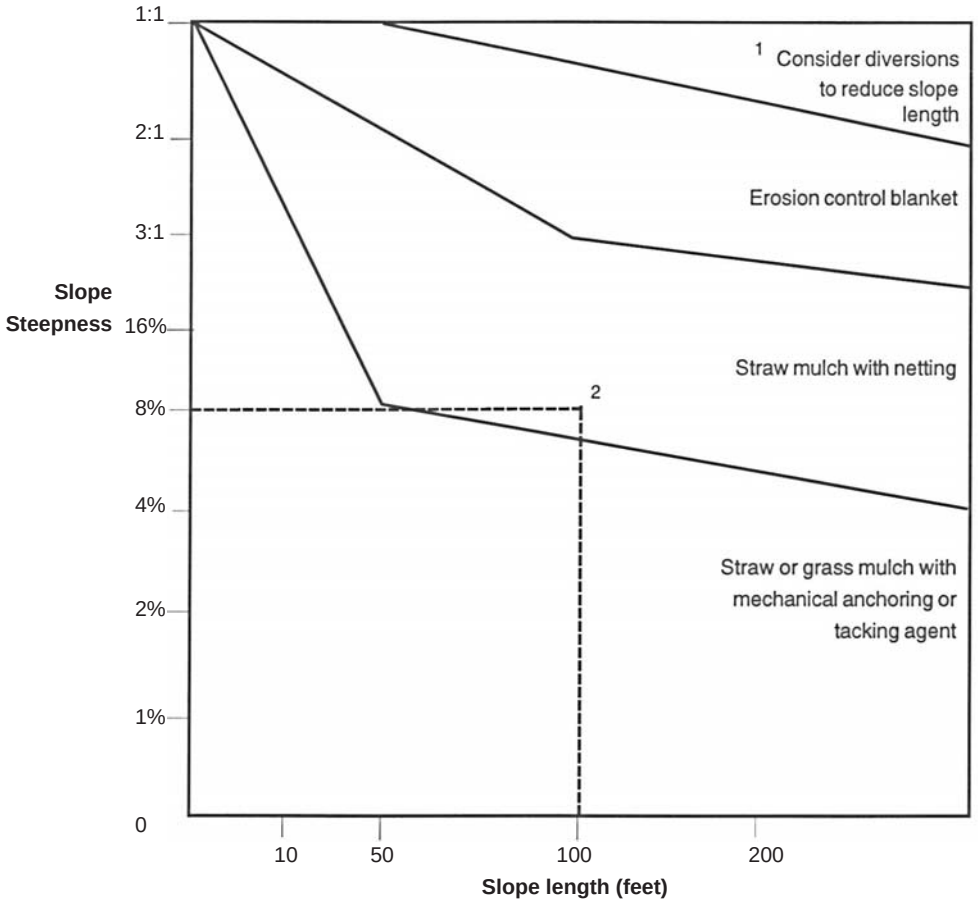
Anchor straw or wood cellulose mulch by one of the following methods:

- Crimp with a weighted, straight, notched disc or a mulch anchoring tool to punch the straw into the soil.
- Tack with a liquid tackifier designed to hold mulch in place. Use suitable spray equipment and follow manufacturer's recommendations.
- Cover with netting, using a degradable natural or synthetic mesh to hold mulch materials in more erosive areas. The netting should be anchored according to manufacturer's specifications (See *Erosion Control Blankets*).

Table 5.10 Typical Mulching Materials and Application Rates

	Material	Rate per Acre	Requirements	Installation/Uses
Organic Mulches:	Straw	1 1/2 - 2 1/2 tons	Dry, unchopped, unweathered; free of weed seeds and rot;	Spread by hand or machine 1.5 to 2.5 inches deep; must be tacked or tied down.
	Wood fiber, wood cellulose, recycled newsprint, bonded fiber matrix	1 - 2 tons	Double the application rate for erosion control on critical areas	Use with power mulcher or hydroseeder; may be used to tack straw on steep slopes. Do not use in hot, dry weather.
	Wood chips	10 - 20 tons	Air dry. Add Nitrogen fertilizer, 20 to 25 lbs of N/ton of mulch	Apply with blower, chip handler or by hand. Not for fine turf areas. Most effective around trees and shrubs. Not recommended for mowed areas.
	Bark	35 yd^3	Air dry, shredded or hammermilled or chips. Add Nitrogen fertilizer, 20 to 25 lbs of N/ton of mulch	Apply with mulch blower, chip handler or by hand. Do not use asphalt tack. Resistant to wind blowing. Most effective around trees and shrubs. Not recommended for mowed areas.
Nets, Mats and Roving:	Netting	Cover area	Uniform natural or synthetic netting. Used with or without organic mulch, depending on product.	Withstands water flow. Must be anchored.
	Erosion control mats/blankets	Cover area	Use without additional mulch.	Suitable for steep areas and areas with concentrated water flow. Must be anchored with good blanket-to-soil contact.
	Fiberglass roving	1/2 - 1 ton	Continuous fibers of drawn glass bound together with a nontoxic agent. Use with organic mulch.	Apply with compressed air ejector. Tack with emulsified asphalt at rate of 25 - 35 gal/1000 ft^2.
Tackifiers	Mulch Tackifiers: Many commercial products	Follow manufacturer's specifications	Biodegradable powders, water dispersable.	Use to hold mulch on steep or wet areas. Apply with suitable spray equipment at manufacturer's recommended rate.
Soil Binders:	Chemical Stabilizers: Many Trade Names	Follow manufacturer's specifications.	Use for temporary stabilization of soil.	Not beneficial to plant growth. Do not attempt to seed/mulch over the soil binder.

Source: adapted from North Carolina Field Manual, 1991



1 For slopes steeper than 1:1, consider building a diversion above slope to divert water.
2 Example: An 8% slope 100' long requires a straw mulch with netting.

Figure 5.4 General Mulch Recommendations to Protect from Splash and Sheet Flow *

Source: Adapted from Minnesota "Protecting Water Quality in Urban Areas," 1991

* Recommendations for specific sites may vary depending upon local conditions.

Use heavy natural nets without additional mulch, synthetic netting with additional mulch or erosion control mats/blankets to control erosion on steep slopes and in areas needing a higher degree of protection such as waterways, swales and diversion channels. These commercial materials vary greatly in longevity, strength, heaviness and the rate of water flow they can handle.

Install netting and mats/blankets according to manufacturer's specifications making sure materials are properly anchored (See *Erosion Control Blankets*).

Construction Verification

Check materials and installation for compliance with specifications.

Troubleshooting

Consult with qualified design professional if any of the following occur:

- Variations in topography on site indicate the mulching materials will not function as intended; changes in plan may be needed.
- Design specifications for mulching materials or seeding requirements cannot be met; substitution may be required. Unapproved substitutions could result in erosion or seeding failure.

Maintenance

Inspect all mulched areas periodically and after rainstorms for erosion and damage to the mulch. Repair promptly and restore to original condition. Continue inspections until vegetation is well established. Keep mower height high if plastic netting is used to prevent netting from wrapping around mower blades or shaft.

Common Problems

Erosion, washout and poor plant establishment—repair eroded surface, reseed, remulch and anchor mulch.

Mulch is lost to wind or stormwater runoff—reapply mulch and anchor by crimping, netting or tacking.

Mulch not anchored in channel; resulting in channel bottom eroding—

repair damage, replace mulch and anchor or install appropriate channel liner.

Mulch deteriorates before plant establishment—reapply mulch, do not hydromulch in winter.

Tree Protection

Practice Description

To preserve and protect trees during development for their aesthetic and economic value, and their aid in energy conservation, landscaping, air purification and erosion control. This practice applies to any construction site where desirable trees are present.

Trees can be damaged or killed by direct contact with construction equipment, compaction of the soil within the root zone of the tree, changes in the elevation of the water table due to site grading, and by construction chemicals and refuse. Although damage may be unseen, it can result in tree death within three or four years. Damage to the root zone is the leading factor in the unintentional destruction of trees.

Recommended Minimum Requirements

Prior to start of construction, desirable trees (including sensitive species) should be selected and marked for protection by a registered design professional. A grading plan which indicates the location of protected trees, utility trenches and other protected areas such as floodplains, steep slopes, wetlands and streambanks should be made available to field personnel. Areas for parking equipment should be designated.

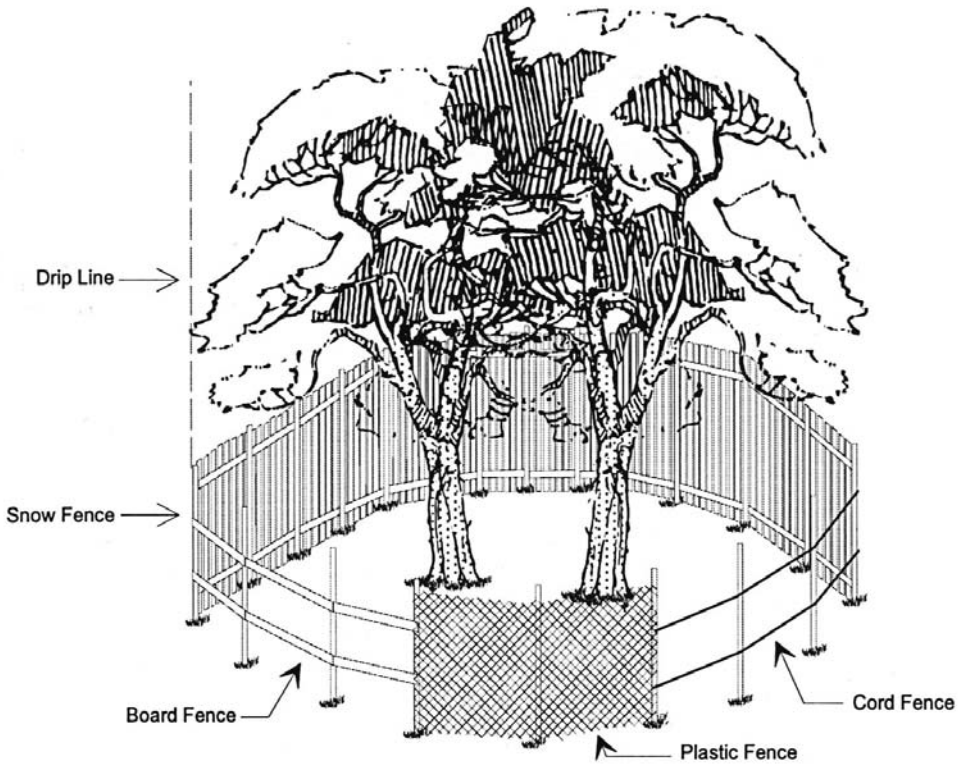
- **Temporary Fences:**
  Placement: At the dripline or tree canopy perimeter (For tree species that are sensitive to root damage, place at the critical root radius to ensure tree's survival.)
  Materials: Snow, board, plastic or cord fence

- **Restricted Activities:** Use temporary fence to restrict traffic, excavation, parking, storing materials and filling under the tree canopy (or at the critical root radius to ensure survival of sensitive species).

- **Permanent Drains:** Install permanent drains in areas where site grading may be expected to cause water table saturation of the root zone (See *Subsurface Drain*).

- **Grading:** Minimize cut and fill near trees by following the natural contours, and locating roadways, storage areas and parking pads away from desired tree stands.

- **Trenching:** Minimize trenching near tree canopy perimeter and place several utilities in one trench when possible.



Tree Fencing Methods

Up to 90 percent of trees' roots may be in the top 12 inches of soil. Typically, roots spread out from two to three times the width of the canopy or tree's branches.

Build a barrier at the dripline (or at the critical root radius for sensitive species) to prevent damage from soil compaction, cut and fill operations and physical wounds.

To calculate the critical root radius: measure the tree's diameter at breast height (4½ feet above the ground), multiply that number by 1.5 feet. For example, a tree with a d.b.h. of 20 inches will have critical root radius of 30 feet; a diameter of 60 feet.

Figure 5.5 Erecting Barriers for Tree Protection

Source: Adapted from MU Guide 6885

Construction

Install temporary fences at tree dripline (at the critical root radius for sensitive tree species). To avoid compaction of the soil around desired trees, keep traffic, equipment and supplies off of the root systems. Figure 5.5 shows the correct method of erecting barriers for tree protection.

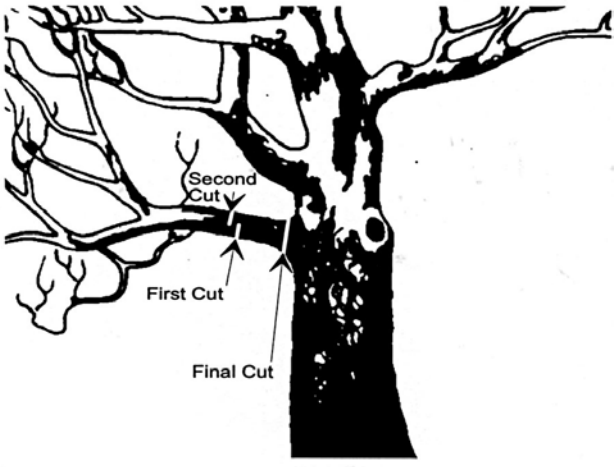
Route underground utilities according to plan. If possible, combine in one trench and route away from trees and potential planting sites.

Use a brush cutter, rotary axe, or cut by hand instead of grading off brush to maintain a site within the tree canopy perimeter.

Note: If grading beneath a tree's canopy is indicated on the plan:

Prior to construction activities, prune low hanging branches that may be damaged by equipment. To avoid tearing the bark from the tree while pruning, remove large branches with a stub-cut method. Figure 5.6 illustrates correct methods of pruning.

Minimize grading beneath the tree canopy. Avoid placing fill, or removing leaf litter or soil in the ungraded areas. Cut large roots instead of tearing them with equipment.



Stub-cut Method: First, make an undercut about one foot from the trunk. Then, cut through the branch near the first cut. Leave the tree's branch collar intact during the final cut to promote healing and prevent the spread of decay.

Figure 5.6 Proper Method of Pruning

Source: Adapted from MU Guide 6866

Construction Verification

Check the construction site to verify that protective measures are being observed.

Troubleshooting

Consult with registered design professional if any of the following occur:

- A protected tree is accidentally injured by construction activities.
- If grade around protected tree must be raised.

Maintenance

Remove fence around protected trees only after all construction is completed.

In spite of these precautionary steps some damage may occur to desired trees. If damage does occur, repair it immediately. Repair damage to limbs or roots by cutting off the damaged areas. Repair damage to bark by trimming the perimeter of the damaged area.

Inspect trees for signs of stress; insect, disease and drought damage. Stressed trees should be watered during dry periods. Soak area under the canopy to a depth of 12 to 18 inches. Avoid fertilizing severely stressed trees until they become reestablished a year or two later. Treat insect and disease problems with a pesticide, if necessary.

Common Problems

Compaction causes moderate signs of damage such as wilting, early leaf drop in the fall or slow growth—aerate the soil by pulling 12- to 18- inch deep cores to assist movement of moisture and oxygen into the soil, then backfill with compost.

Trees that are killed during construction—remove after site completion and replace with new trees.

Erosion Control Blankets

Practice Description

To aid in controlling erosion on critical areas by providing a protective cover made of straw, jute, wood or other plant fibers; plastic, nylon, paper or cotton. This practice is best utilized on slopes and channels where the erosion hazard is high, and plant growth is likely to be too slow to provide adequate protective cover. Erosion control blankets are typically used as an alternative to mulching but can also be used to provide structural erosion protection. Some important factors in the choice of a blanket are: soil conditions, steepness of slope, length of slope, type and duration of protection required to establish desired vegetation, and probable sheer stress.

K. Grimes, SWCD. St. Charles Co.

Follow manufacturer's recommendations to successfully install erosion control blankets or matting. The manufacturer of this high velocity blanket called for stapling every two feet and a check slot wherever two sections were joined. This blanket was used to protect soil and establish grass in a waterway on the August Busch Memorial Conservation Area.

Recommended Minimum Requirements

Prior to the start of construction, the application of erosion control blankets should be designed by a qualified professional and plans and specifications should be available to field personnel. The field inspector should verify that installation is in accordance with the plans and specifications.

Numerous products designed to control erosion are available. Product installation procedures for manufactured erosion control blanket products should always be available from the manufacturer. Table 5.11 lists some of the more common products available.

TABLE 5.11 Types of Erosion Control Blankets

Type of Erosion Control	Main Use	Comments
Netting	Synthetic or natural fiber mesh installed over disturbed area to hold organic mulch and/or seed in place.	Provides minimal structural erosion resistance. Mulch applied using standard procedures.
Biodegradable Erosion Control Blanket	Natural fiber blanket held together by netting to provide temporary erosion protection on slopes up to 1:1; and channels with permissable shear stress up to 4 lbs./ft.	Provides 1- to 5-year protection from erosion. Metal staples used as anchors.
Permanent Erosion Control Blanket	Synthetic blanket material which provides permanent erosion control on slopes up to 1:1; channels with increased water flow velocities and increased shear stress.	Provides minimal protection from wave action around ponds and lakes. Permanent erosion control blankets extend the limits of vegetation. Metal staples used as anchors.
Turf Reinforcement Mat	3-dimensional permanent synthetic mat that provides a matrix to greatly reinforce the root system of the desired vegetation for permanent erosion protection in high flow channels and on critical slopes.	Provides a substantial increase in erosion resistance. May provide erosion protection equivalent to stone or concrete liners.

Source: Adapted from North Carolina Field Manual, 1991

Construction

Site Preparation

Grade the site in accordance with the approved design to a smooth and uniform surface, free of debris.

Add and incorporate topsoil where needed.

Make sure seed bed is firm yet friable.

Seed and fertilize as shown on the design plan.

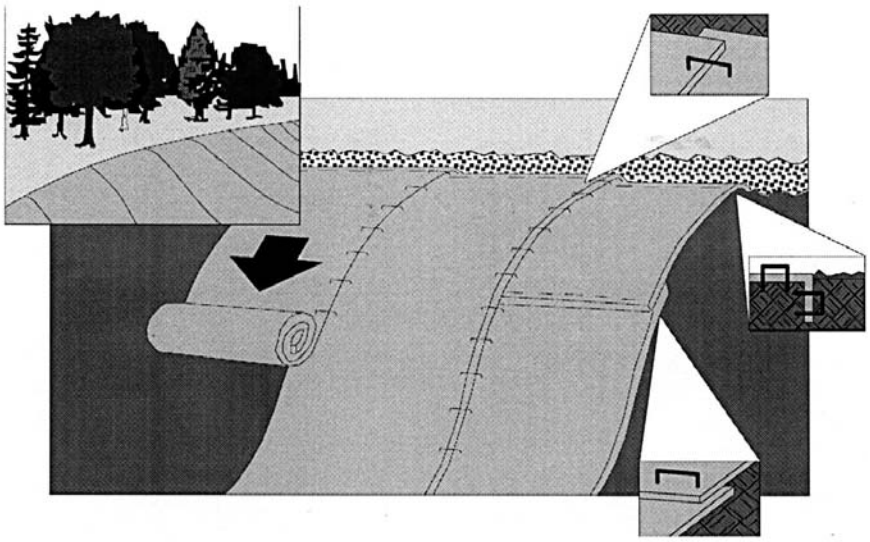


Figure 5.7 Typical Installation of Erosion Control Blankets on a Slope *

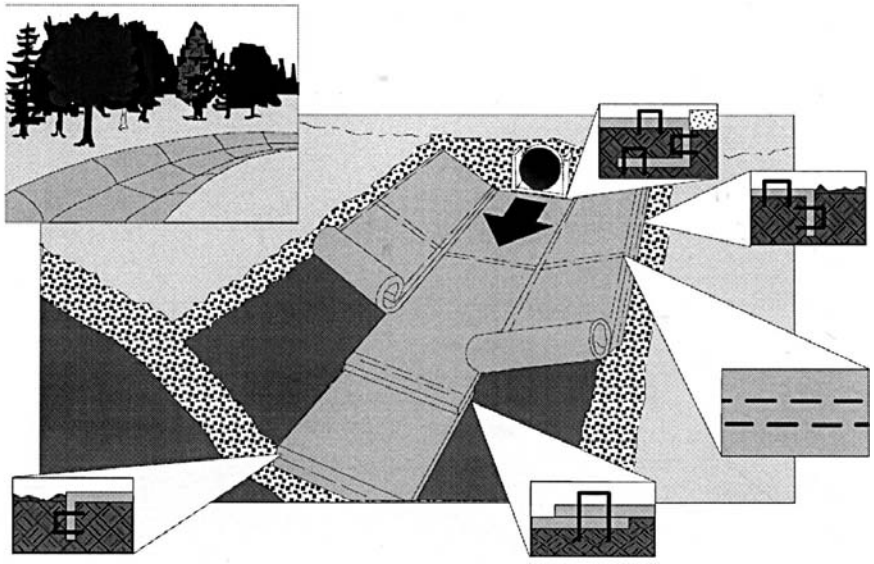


Figure 5.8 Typical Installation of Erosion Control Blankets in a Channel *

* Consult manufacturer for recommendations on proper installation of staple patterns.

Blanket Installation

Erosion control products should be installed in accordance with the manufacturers' recommendations and specifications, including check slots and stapling materials.

Anchor product so that a continuous, firm contact (no tenting) with the soil surface/seed bed is maintained.

Note: Failure to do the above could result in soil erosion which would require regrading and reseeding.

Construction Verification

Check finished grade, dimensions and staple spacing of erosion control blankets. Check materials for compliance with specifications.

Troubleshooting

Consult with registered design professional if any of the following occur:

- Movement of the blanket or erosion under the blanket is observed.
- Variations in topography on site indicate erosion control mat will not function as intended; changes in plan may be needed, or a blanket with a shorter or longer life may be needed.
- Design specifications for seed variety, seeding dates or erosion control materials cannot be met; substitution may be required. Unapproved substitutions could result in failure to establish vegetation.

Maintenance

Inspect after storm events, until vegetation is established, for erosion or undermining beneath the blankets. If any area shows erosion, pull back that portion of the blanket, add tamped soil and reseed; then resecure the blankets.

If blankets should become dislocated or damaged, repair or replace and resecure immediately.

Common Problems

Poor contact between the soil and the erosion control blanket results in surface water flowing under rather than over the blanket, causing erosion—retrench or reanchor to direct water over blanket.

Blanket inadequately or improperly stapled results in tenting, blanket movement or displacement—reinstall and ensure blanket is properly anchored.

Unstable slope results in blanket or slope failure—determine cause of slope failure, stabilize slope and reinstall blanket.

Land Grading

Practice Description

Reshaping the ground surface to provide suitable topography for buildings, facilities and other land uses, to control surface runoff, and to minimize soil erosion and sedimentation both during and after construction. This practice applies to sites where the existing topography must be modified to prepare for another land use, or where adapting proposed development to the existing landscape can reduce the erosion potential of the site and the cost of installing erosion and sedimentation control measures.

Slope breaks, such as diversions or benches, can be used to reduce the length of continuous slopes and reduce erosion (See *Temporary* or *Permanent Diversions*).

C. Rahm, NRCS. St. Charles Co.

Lot benching can shorten slope length and prevent erosion while improving the homeowner's yard.

Recommended Minimum Requirements

Prior to start of construction, the site grading plan should be designed by a qualified professional. The grading plan should show disturbed areas, cuts, fills and finished elevations for all graded areas. Plans and specifications should be referred to by field personnel throughout the construction process.

- **Scheduling Construction Activities:** So that the least area is disturbed at one time

- **Slope Breaks:** Refer to plan. Table 5.12 provides suggested guidelines for spacing of slope breaks.

Table 5.12 Guidelines for Spacing Slope Breaks

Slope	Spacing (ft)
33-50%	20
25-33%	40
15-25%	60
10-15%	80
6-10%	120
3-6%	200
< 3%	300

Source: Adapted from North Carolina Field Manual, 1991

- **Surface Runoff:** Avoid disturbing natural drainageways, if possible. At each slope break, intercept runoff and channel to storm drains or stabilized watercourses. If runoff is laden with sediment, protect drain inlets with a filter or divert water to a sediment trap or basin according to the site grading plan (See Inlet Protection, *Temporary Sediment Trap* and *Sediment Basin*).

- **Erosion Control:** Graded areas should be stabilized with mulch, vegetation, crushed stone, riprap or other measures as soon as work is completed, or if work is interrupted for 30 or more working days.

- **Slopes To Be Vegetated:** 2:1 or flatter; 3:1 or flatter where maintained by tractor or other equipment. Slopes should be roughened during grading operations to retain water, increase infiltration and promote vegetative growth. Slope should be protected from surface runoff while vegetation is being established (See *Diversions, Perimeter Protection*).

- **Borrow And Disposal Areas:** As shown on the grading plan; or no closer than 50 feet to a streambank in the absence of a specification

- **Outlet:** Stable channels and waterways should be provided for runoff from the disturbed area to retain sediment on site.

Construction

Site Preparation

Erosion and sedimentation control measures should be installed as specified and in the sequence shown on the design plan.

Determine exact location of underground utilities.

Remove and stockpile topsoil (see *Topsoiling*) if subsoils will not support plant growth.

Clear and grub areas to be filled to remove trees, vegetation, roots and other debris.

Check fill to make sure it is does not contain brush, rubbish, oversized rocks or other objectionable material.

Place fill in layers and compact as specified by the grading plan. Do not use material that is frozen, excessively soft or has high organic content.

Do not place fill on frozen subgrade.

Grading

Construct slope breaks as shown on the grading plan, or in accordance with the recommendations of Table 5.12. A typical slope break is illustrated in Figure 5.9.

Keep diversions and other water conveyance measures free of sediment during all phases of development.

Install subsurface drains (See *Subsurface Drains)* in areas where seepage interferes with the grading operations, or where required to improve slope stability or soil bearing capacity.

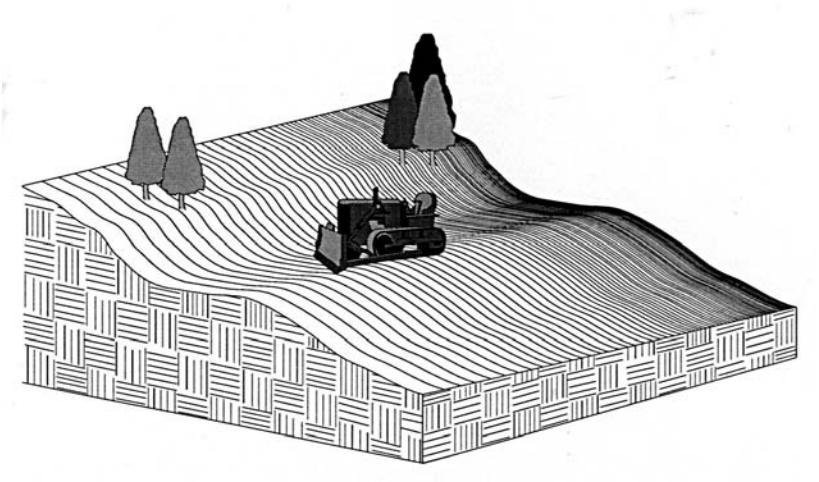


Figure 5.9 Typical Slope Break

Permanently stabilize graded areas immediately after final grading is completed. Use temporary stabilization measures on graded areas when work is to be interrupted or delayed for 30 working days or longer.

Construction Verification

Check all finished grades for conformance with grading plan and correct as necessary.

Troubleshooting

Consult with design professional if any of the following occur:

- Variations in topography on site indicate grading plan will be ineffective or unfeasible.
- Seepage is encountered during construction. It may be necessary to install drains.
- Design specifications for seed variety, seeding dates or erosion control materials cannot be met. Substitutions may be required. Unapproved substitutions could result in erosion and lead to failure of erosion control measures.

Maintenance

Periodically check all graded areas and the related erosion and sedimentation control practices, especially after heavy rainfalls. Clean sediment out of diversions and other structures as needed. If washouts or breaks occur, repair them immediately.

Common Problems

Slope breaks are too far apart; results in rill and gully erosion—construct intermediate slope breaks.

Subgrade is soft or has high organic content; can hinder proper compaction of fill—undercut and replace unsuitable subgrade soil.

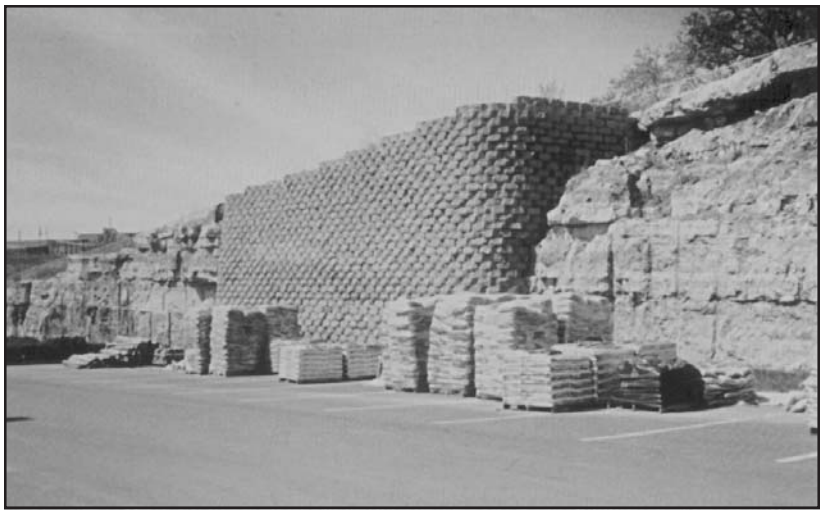
High water table results in excessive wetness or seepage; can hinder grading operations or result in slope instability or reduced bearing capacity—install subsurface drains to lower water table.

Retaining Walls

Practice Description

A constructed wall used to eliminate steep slopes between areas that have abrupt changes in grade. This practice is used to replace cut or fill slopes in confined areas or where a wall is necessary to achieve stable slopes.

Retaining walls can be constructed of reinforced concrete, treated timbers, gabions, reinforced earth (a system of face panels and buried reinforcement strips), or other manufactured products such as interlocking concrete blocks.



Deirdre Vest, NRCS. Taney Co.

Retaining walls are highly engineered structures. Each one should be individually designed to address site specific conditions. This one was installed in front of a retail store in Branson.

Recommended Minimum Requirements

Prior to start of construction, retaining walls should be designed by a registered design professional. Plans and specifications should be referred to by field personnel throughout the construction process. Designing retaining walls is a complicated process. Each situation requires an individual design which depends on specific site conditions.

Construction

Site Preparation

Completely remove stumps, roots and other debris from the construction area. Fill depressions caused by clearing and grubbing operations with clean, non-organic soil.

Determine exact location of underground utilities.

Retaining walls should be constructed to the lines and grades shown on the plans.

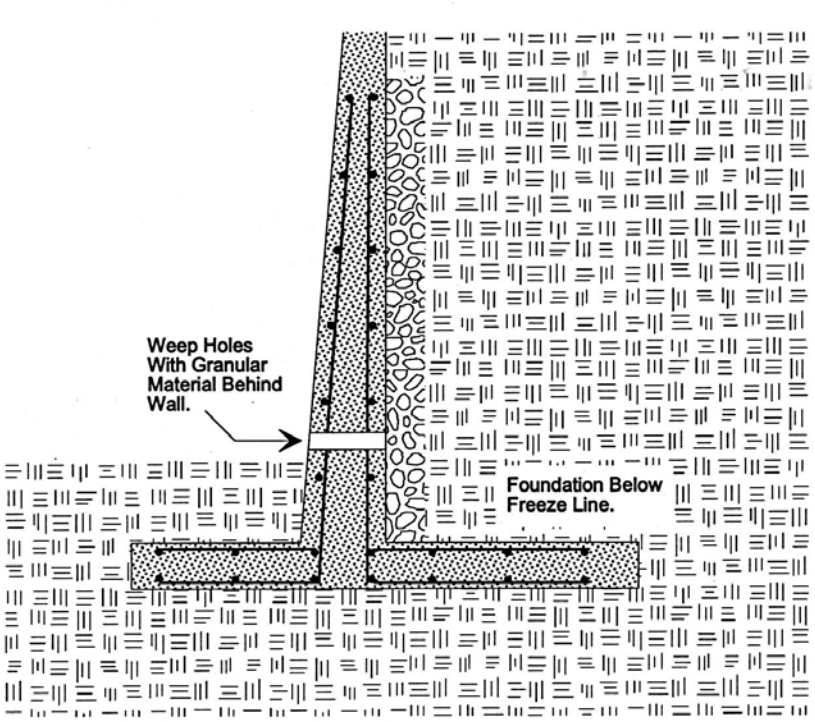


Figure 5.10 Cross Section of Typical Reinforced Concrete Retaining Wall

Concrete Wall Installation

Place reinforcing steel in strict accordance with the design plans and maintain the proper position during the placing of concrete. Concrete should be placed in horizontal layers not exceeding 24-inches in thickness or as specified in the design, and consolidated by mechanical vibrating equipment supplemented by hand-spading, rodding or tamping.

Place concrete in sturdy wood or metal forms, adequately supported to prevent deformation. Forms should be oiled prior to placement to prevent bonding between concrete and forms.

If possible, concrete should not be placed during inclement weather or periods of temperature extremes. If temperature extremes cannot be avoided, consult American Concrete Institute (ACI) guidelines for placement of concrete during such extremes.

Concrete should be allowed to cure as called for in the plans and specifications. Typically, the surface should be kept wet during curing by covering it with wet burlap sacks or other means. Design strengths should be confirmed by laboratory tests on representative cylinders made during concrete placement. Form work should be left in place until the concrete attains design strength.

Drains and weep holes should be installed as shown on plans.

Modular Block Wall Installation

Prepare a leveling pad of compacted, crushed rock (typically 6 inches thick and 18 inches wide). Place the first row of modular blocks on the leveling pad (not a footing, as the geosynthetic reinforcement will bear the weight of the block and the backfill).

Install additional modular blocks and geosynthetic reinforcement (geogrid or geotextile) according to design plan. A typical modular block wall is illustrated in Figure 5.11.

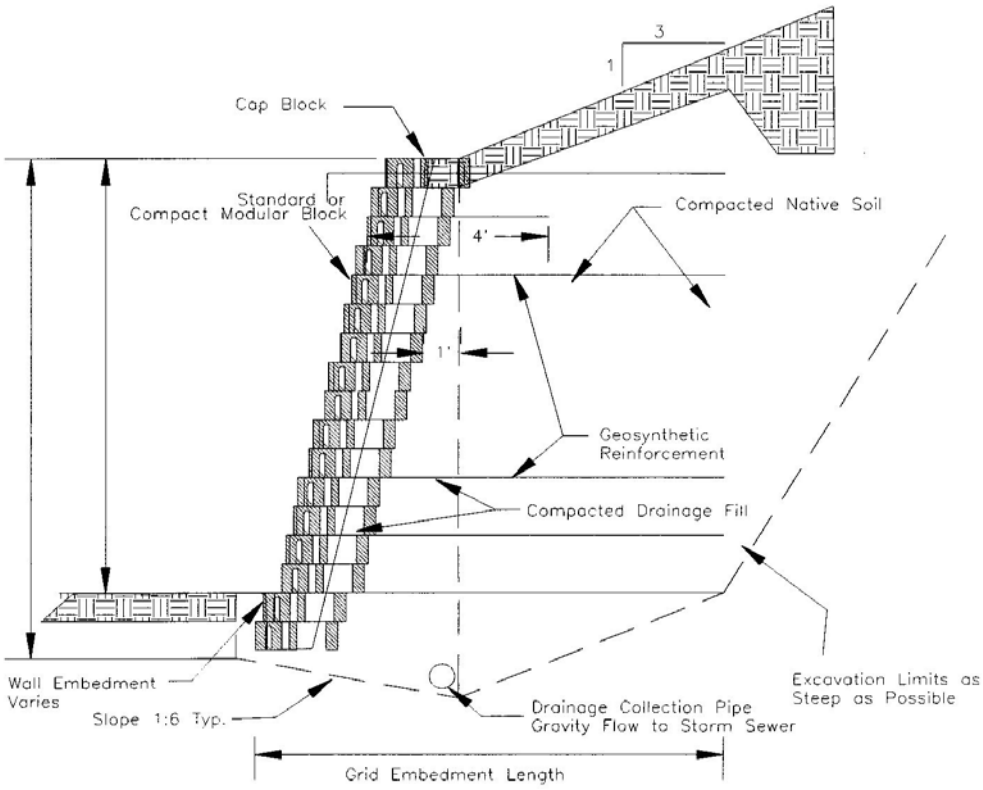


Figure 5. 11 Typical Modular Block Wall

Timber Wall Installation

Timbers should be new pressure-treated members having a design life consistent with that of the project and free of splits and deep cracks.

Proper tiebacks are essential to the stability of timber retaining walls. Install tiebacks according to design plans.

Installation of Manufactured Products

Specifications for manufactured products should be provided by the manufacturer or in the design plan. Inspect all such materials for damage prior to installation.

Backfill

Backfill for all wall types should be placed carefully in layers not exceeding 8 inches (loose) and compacted with hand-operated tampers. The degree of compaction should be specified in the design as a percentage of the maximum dry density (determined by testing). Before compacting, the soil should be moistened or dried as necessary to obtain optimum moisture content. Backfill should not be placed on surfaces that are muddy, frozen or contain frost or ice.

Backfill for retaining walls built of manufactured products such as reinforced earth or interlocking concrete blocks should be placed according to manufacturer's recommendations. Place tiebacks or geosynthetic reinforcements horizontally into the fill at the designed locations and lengths.

Nonwoven filter fabric should be used behind timber or modular block walls to help keep soil in place.

Construction Verification

Check finished retaining wall for conformance with design specifications. Also, check for cracks or movement.

Troubleshooting

Consult with registered design professional if any of the following occur:

- Seepage is encountered during construction. It may be necessary to install drains.
- Variations in topography on site indicate retaining wall will not function as intended.
- Design specifications for concrete, timbers, backfill or other materials cannot be met; substitutions may be required. Unapproved substitutions could lead to failure.

- Poor foundation soils are encountered under the proposed wall location.

Maintenance

Inspect retaining walls periodically and after heavy rains for cracks, undercutting of the foundation, piping erosion, wetness or movement.

Repair cracks according to manufacturer's recommendations.

Common Problems

Poor foundation preparation for concrete walls; results in movement of base, cracking or complete failure of the wall—inspect foundation thoroughly before concrete placement.

High soil and water pressures result in structural failure of the wall—consult design professional and rebuild.

Concrete poured during inclement weather conditions; results in excessive spalling, cracking or erosion of concrete surface—prohibit placement of concrete during inclement weather or follow accepted guidelines for such conditions.

Concrete does not meet specification; results in low strength, cracking, spalling or other undesirable conditions—perform sufficient testing to verify concrete specifications.

Timbers have excessive splits or deep cracks; results in accelerated weathering of the members—replace damaged members.

Wall backfilled before adequate curing of concrete; results in structural failure of wall—consult design professional and rebuild.

Piping of backfill or discontinuities in wall; results in loss of backfill and increased erosion behind structure—excavate fill, install filter behind wall and backfill.

Improper compaction of soil behind the wall face; results in wall movement—consult design professional, excavate fill and rebuild.

Dust Control

Practice Description

Includes a wide range of techniques that reduce movement of windborne soil particles (dust) from disturbed soil surfaces. This practice applies to construction routes and other disturbed areas where on-site and off-site damage or hazards may occur if dust is not controlled.

C. Rahm, NRCS. St. Charles Co.

Spraying water is effective for dust control on haul roads, although it must be frequently repeated during hot days or heavy traffic periods.

Recommended Minimum Requirements

Dust control measures should be designed by a qualified professional and plans and specifications should be made available to field personnel prior to start of construction.

Whenever possible, leave undisturbed vegetated buffer areas between graded areas.

- **Scheduling:** Plan and schedule construction operations so that the smallest area is disturbed at one time
- **Erosion Control:** Install surface stabilization measures immediately after completing the land grading

Construction

Any combination of the following may be used to help reduce the dust and air pollution at a construction site.

- **Vegetative Cover:** For areas not subjected to traffic, vegetation provides the most practical method of dust control (See *Temporary* or *Permanent Seeding*).

- **Sprinkling:** The site can be sprinkled with water until the surface is moist. This practice is effective for dust control on haul roads or other traffic routes, but constant repetition is required for effective control.

- **Barriers:** Board fences placed perpendicular to the prevailing winds at intervals of 15 times the barrier height can control blowing soil. In areas of known dust problems, windbreak vegetation should be preserved.

- **Street Cleaning:** Use of a street sweeper in the area of a development site can aid in controlling dust.

- **Mulching:** This practice offers a fast and effective means of controlling dust when properly applied. Binders or tackifiers should be used to tack organic mulches (See *Mulching*). Mulching is not recommended for areas with heavy traffic.

If the following materials or any other chemicals are used for dust control, please contact the Missouri Department of Natural Resources, Water Pollution Control Program, or the Kansas Department of Health and Environment for permit requirements.

- **Calcium Chloride:** This material is best used on road surfaces. It can be applied by a mechanical spreader at a rate that keeps the surface moist.

  Note: This method may cause restrictions for vegetation establishment.

Construction Verification

- **Spray-on Adhesives:** Spray-on adhesives are effective on non-organic soils and many will withstand heavy traffic loads. Table 5.13 presents examples of spray-on adhesives that have been used successfully for dust control.

Table 5.13 Application Rates for Spray-on Adhesives used in Dust Control

Adhesive	Water Dilution (adhesive: water)	Type of Nozzle	Application Rate (gallons/acre)
Anionic Asphalt Emulsion	7:1	Coarse	1200
Latex Emulsion	12.5:1	Fine	235
Resin in Water	4:1	Fine	300
Acrylic Emulsion (Non-traffic)	7:1	Coarse	450
Non-Acrylic Emulsion (Traffic)	3.5:1	Coarse	350

Source: Virginia Erosion and Sediment Control Handbook, 1993

Check construction site during vehicular traffic or windy conditions to see if measures are working adequately.

Troubleshooting

Consult with a qualified professional if the following occurs:

- Spray-on adhesives are specified. A permit may be needed.

Maintenance

Maintain dust control measures continuously throughout dry weather periods, until all disturbed areas have been stabilized.

Common Problems Drought conditions; results in dry soils and increase in dust problems—use greater precautions during these periods.

Soil Bioengineering for Slope Protection

Practice Description

The use of live, woody vegetative cuttings to increase slope stability and repair slope failures such as shallow sloughs or slides. When the vegetative cuttings are placed in the ground, roots develop and foliage sprouts. Soil bioengineering has the benefits of temporary or permanent vegetation: reduced erosion, off-site sedimentation and runoff velocity, and increased infiltration. Also, as the woody vegetation grows the roots mechanically reinforce the soil and provide greater protection than grass or a mechanical practice alone.

There are two approaches which can be used: woody vegetation systems and woody vegetation systems combined with simple inert structures. The structural part of the system helps establish vegetation on steep slopes or in areas subject to extreme erosion. Both systems provide immediate protection and grow stronger with time as the vegetation becomes established.

Willows and other live stakes will root and sprout rapidly to protect slopes. The roots form an interlocking mat to hold soil in place, while the foliage protects the soil surface. These willows, planted along Hinkson Creek in Columbia, were 3 to 5 feet tall within six months.

Doug Wallace, NRCS. Boone Co.

Soil bioengineering is advantageous where there is minimal access for equipment and workers, and in environmentally sensitive areas where minimal site disturbance is required. It is particularly suited for small, highly sensitive or steep sites. Most techniques can also be used for

stream channel or bank protection. Once established, woody vegetation becomes self-repairing and needs little maintenance.

More information on bioengineering practices can be obtained from your local National Resources Conservation Service/Soil and Water Conservation District and the Missouri Department of Conservation.

Recommended Minimum Requirements

Prior to start of construction, bioengineering practices should be designed by a registered design professional and/or an interdisciplinary team with knowledge of mechanical, biological and ecological concepts. Plans and specifications should be referred to by field personnel throughout the construction process.

- **Plant Species:** Native species that root easily such as willow; suitable for the intended use and adapted to site conditions. Plants are usually harvested from a nearby local area.

- **Cutting Size:** Normally 1/2 to 2 inches in diameter and from 2 to 6 feet long (length will depend on project requirements)

- **Harvesting:** Cut plant materials at a blunt angle, 8 to 10 inches from the ground, leaving enough trunk so that cut plants will regrow

- **Transportation and Handling:** Bundle cuttings together on harvest site, removing side branches. Keep material moist. Handle carefully during loading and unloading to prevent damage. Cover to protect cuttings from drying out.

- **Installation Timing:** Deliver to construction site within 8 hours of harvest and install immediately, especially when temperatures are above 50° F. Store up to 2 days if cuttings are "heeled in" moist soil, shaded and protected from wind.

- **Season:** Install during plants' dormant season, generally late October to March.

- **Soil:** Must be able to support plant growth. Compact to fill voids and maintain good branch cutting-to-soil contact.

- **Velocities:** Up to 6 feet per second for woody vegetation alone. Include simple structures with woody vegetation for velocities over 6 feet per second. Use the velocity associated with the peak discharge of the design storm (see *Streambank Protection* section for structural protection alternatives).

- **Erosion Control:** Minimize the size of all disturbed areas and stabilize as soon as each phase of construction is complete. Seed and mulch bare areas on 3:1 or flatter slopes. Use netting, tackifiers or blankets with seeding on slopes steeper than 3:1.

Construction

Site Preparation

Observe applicable government regulations.

Determine exact location of all underground utilities.

Locate source of live rooted plants or cuttings as specified in design plan. Local sources of native plants are ideal to use. Purchase of materials from commercial sources may be necessary to comply with local regulations.

Prepare site by clearing, grading and shaping according to design plan. Stockpile topsoil to be used as backfill. Stabilize the base before any structural or streambank work is done.

Installation

Prepare trenches or benches in cut and fill slopes according to the design plan. Construct structural components such as cribwalls, walls or riprap according to the design plan (See *Structural Protection* in this section).

Install live cuttings, checking angle of placement and orientation. Secure cuttings with stakes or as specified in plan. Time the work so that plants are in a dormant state to enhance the success of establishment.

Fertilize and lime according to soil test results as specified in the design plan.

Install filter fabric if specified in the design plan. Backfill over the vegetative cuttings, compacting the soil to achieve good live branch cutting-to-soil contact. Fill any voids around the plant materials.

Check to see that adequate soil moisture is present to encourage rooting and growth. Water, if necessary.

Woody Vegetative Protection

Live staking, live fascines, brushlayers, branchpacking and live gully repair are soil bioengineering practices that use the stems or branches of living plants as a soil reinforcing and stabilizing material. Eventually the vegetation becomes a major structural component of the bioengineered system.

Live Stake

Live staking is the use of live, rootable vegetative cuttings, inserted and tamped into the ground. As the stakes grow, they create a living root mat that stabilizes the soil. Use live stakes to peg down surface erosion control materials. Most native willow species root rapidly and can be used to repair small earth slips and slumps in wet areas.

Installation: To prepare live material, cleanly remove side branches, leaving the bark intact. Use cuttings 1/2 to 1 1/2 inches in diameter and 2 to 3 feet long. Cut bottom ends at an angle to insert into soil. Cut top square.

Tamp the live stake into the ground at right angles to the slope, starting at any point on the slope face. Buds should point up. Install stakes 2 to 3 feet apart using triangular spacing with from 2 to 4 stakes per square yard.

An iron bar can be used to make a pilot hole in firm soil. Drive the stake into the ground with a dead blow hammer (hammer head filled with shot or sand).

Four-fifths of the live stake should be underground with soil packed firmly around it after installation. Replace stakes that split during installation.

Live Fascine

Live fascines are long bundles of branch cuttings bound together into sausage-like structures. They should be placed in shallow contour trenches on dry slopes and at an angle on wet slopes to reduce erosion and shallow face sliding. This practice is suited to steep, rocky slopes, where digging is difficult.

Installation: To prepare live materials, make cuttings from species such as young willows or shrub dogwoods that root easily and have long, straight branches.

Make stakes 2 1/2 feet long for cut slopes and 3 feet long for fill slopes.

Make bundles of varying lengths from 5 to 30 feet or longer, depending on site conditions and limitations in handling. Use untreated twine for bundling.

Completed bundles should be 6 to 8 inches in diameter. Orient growing tips in the same direction. Stagger cuttings so that root ends are evenly distributed throughout the length of the bundle.

Install live fascine bundles the same day they are prepared.

Prepare dead stakes such as 2 1/2-foot long, untreated 2- by 4-inch lumber, cut diagonally lengthwise to make two stakes. Live stakes will also work.

Beginning at the base of the slope, dig a trench on the contour large enough to contain the live fascine. Vary width of trench from 12 to 18 inches, depending on angle of the slope. Trench depth will be 6 to 8 inches, depending on size of the bundle.

Place the live fascine into the trench.

Drive the dead stakes directly through the bundle every 2 to 3 feet. Use extra stakes at connections or bundle overlap. Leave the top of the stakes flush with the bundle.

Install live stakes on the downslope side of the bundle between the dead stakes.

Brushlayer

Brushlayering is similar to live fascine systems. Both involve placing live branch cuttings on slopes. However, in brushlayering, the cuttings are oriented at right angles to the slope contour. Use on slopes up to 2:1 in steepness and not over 15 feet in vertical height.

Installation: Starting at the toe of the slope, excavate benches horizontally, on the contour, or angled slightly down the slope to aid drainage. Construct benches 2 to 3 feet wide. Slope each bench so that the outside edge is higher than the inside.

Crisscross or overlap live branch cuttings on each bench. Place growing tips toward the outside of the bench.

Place backfill on top of the root ends and compact to eliminate air spaces. Growing tips should extend slightly beyond the fill to filter sediment. Soil for backfill can be obtained from excavating the bench above.

Space brushlayer rows 3 to 5 feet apart, depending upon the slope angle and stability.

Branchpacking

Branchpacking consists of alternating layers of live branch cuttings and compacted backfill to repair small localized slumps and holes in slopes (no greater than 4 feet deep or 5 feet wide). Use for earth reinforcement and mass stability of small earthen fill sites.

Installation: Make live branch cuttings from 1/2 inch to 2 inches in diameter and long enough to reach from soil at the back of the trench to extend slightly from the front of the rebuilt slope face.

Make wooden stakes 5 to 8 feet long from 2- by 4-inch lumber or 3- to 4-inch diameter poles.

Start at the lowest point and drive wooden stakes vertically 3 to 4 feet into the ground. Set them 1 to 1 1/2 feet apart.

Place a layer of living branches 4 to 6 inches thick in the bottom of the hole, between the vertical stakes, and at right angles to the slope face. Place live branches in a crisscross arrangement with the growing tips

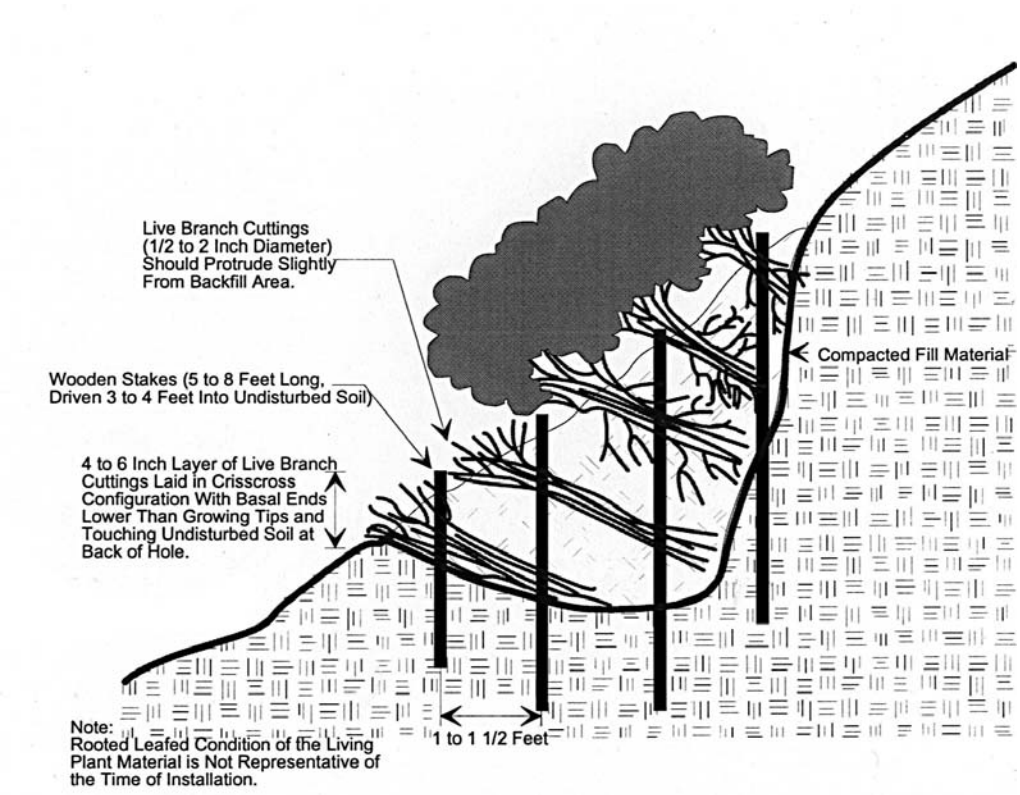


Figure 5.12 Typical Branchpacking Cross Section

Source: NRCS Engineering Field Handbook, 1992.

oriented toward the slope face. Some of the root ends of the branches should touch the back of the hole.

Follow each layer of branches with a layer of compacted soil to ensure soil contact with the branch cuttings.

The final installation should match the existing slope. Branches should protrude only slightly from the rebuilt slope face.

The soil should be moist or moistened to ensure that live branches do not dry out.

Live Gully Repair

Live gully repair uses alternating layers of live branch cuttings and compacted soil to repair small rills and gullies. This practice is limited to rills or gullies less than 2 feet wide, 1 foot deep and 15 feet long.

Installation: Make live branch cuttings 1/2 to 2 inches in diameter and long enough to reach from the soil at the back of the gully and extend slightly from the front of the rebuilt slope face.

Starting at the lowest point of the slope, place a 3- to 4-inch layer of branches at the lowest end of the rill or gully and at right angles to the slope. Cover with a 6- to 8-inch layer of fill soil.

Install the live branches in a crisscross fashion. Orient the growing tips toward the slope face with root ends lower than the growing tips.

Follow each layer of branches with a layer of compacted soil to ensure soil contact with the live branch cuttings and root ends.

Structural Protection

Live cribwalls, vegetated rock gabions, vegetated rock walls and joint plantings are soil bioengineering practices that combine a porous structure with vegetative cuttings. The structures provide immediate erosion, sliding and washout protection. As the vegetation becomes established, the structural elements become less important.

Live Cribwall

A live cribwall consists of a hollow, box-like interlocking arrangement of untreated logs or timber. Use at the base of a slope where a low wall may be required to stabilize the toe of the slope and reduce its steepness or where space is limited and a more vertical structure is required. It should be tilted back if the system is built on a smooth, evenly sloped surface.

Installation: Make live branch cuttings 1/2 to 2 inches in diameter and long enough to reach the back of the wooden crib structure.

Build constructed crib of logs or timbers from 4 to 6 inches in diameter or width. The length will vary with the size of the crib structure.

Starting at the lowest point of the slope, excavate loose material 2 to 3 feet below the ground elevation until a stable foundation is reached.

Excavate the back of the stable foundation (closest to the slope) slightly deeper than the front to add stability.

Place the first course of logs or timbers at the front and back of the excavated foundation, approximately 4 to 5 feet apart and parallel to the slope contour. Place the next set of logs or timbers at right angles to the slope on top of the previous set.

Place each set of timbers in the same manner and nail to the preceding set.

Place live branch cuttings on each set to the top of the cribwall structure with growing tips oriented toward the slope face.

Backfill crib, compacting soil for good root-to-soil contact, seed and mulch.

Vegetated Rock Gabions

Vegetated gabions combine layers of live branches and gabions (rectangular baskets filled with rock). This practice is appropriate at the base of a slope where a low wall is required to stabilize the toe of the slope and reduce its steepness. It is not designed to resist large, lateral earth stresses. Use where space is limited and a more vertical structure is required. Overall height, including the footing, should be less than 5 feet.

Installation: Make live branch cuttings from 1/2 to 1 inch in diameter and long enough to reach beyond the rock basket structure into the backfill.

Starting at the lowest point of the slope, excavate loose material 2 to 3 feet below the ground elevation until a stable foundation is reached. Excavate the back of the stable foundation (closest to the slope) slightly deeper than the front to add stability and ensure rooting.

Place the wire baskets in the bottom of the excavation and fill with rock. Backfill between and behind the wire baskets.

Place live branch cuttings on the wire baskets at right angles to the slope with the growing tips oriented away from the slope and extending slightly

beyond the gabions. Root ends must extend beyond the backs of the wire baskets into the fill material. Place soil over the cuttings and compact it.

Repeat the construction sequence until the structure reaches the required height.

Vegetated Rock Wall

A vegetated rock wall is a combination of rock and live branch cuttings used to stabilize and protect the toe of steep slopes. This system is appropriate at the base of a slope where a low wall may be required to stabilize the toe of the slope and reduce its steepness. It is useful where space is limited and natural rock is available. Height of the rock wall, including the footing, should be less than 5 feet.

Installation: Make live branch cuttings from 1/2 to 1 inch in diameter and long enough to reach the soil behind the rock structure.

Rock should range from 8 to 24 inches in diameter. Use larger boulders for the base.

Starting at the lowest point of the slope, remove loose soil until a stable base is reached, usually 2 to 3 feet below ground elevation. Excavate the back of the stable foundation (closest to the slope) slightly deeper than the front to add stability.

Seat rocks firmly on the foundation material. Place rocks so that their center of gravity is as low as possible, with their long axis slanting inward toward the slope, if possible.

Provide for drainage when a rock wall is constructed adjacent to an impervious surface or in locations subject to deep frost penetration.

A sloping bench behind the wall can provide a base on which to place live branch cuttings during construction. Tamp or place live branch cuttings into the openings of the rock wall during or after construction. The root ends should extend into the soil behind the wall. Orient cuttings at right angles to the slope contour with growing tips protruding from the wall face.

Joint Planting

Joint planting or vegetated riprap involves tamping live cuttings into soil between the joints or open spaces in rocks that have previously been placed on a slope. Use where rock riprap is required. Joint planting is used to remove soil moisture, to prevent soil from washing out below the rock and to increase slope stability over riprap alone.

Installation: Make live branch cuttings from 1/2 inch to 1 1/2 inches in diameter and long enough to extend into soil below the rock surface. Remove side branches from cuttings leaving the bark intact.

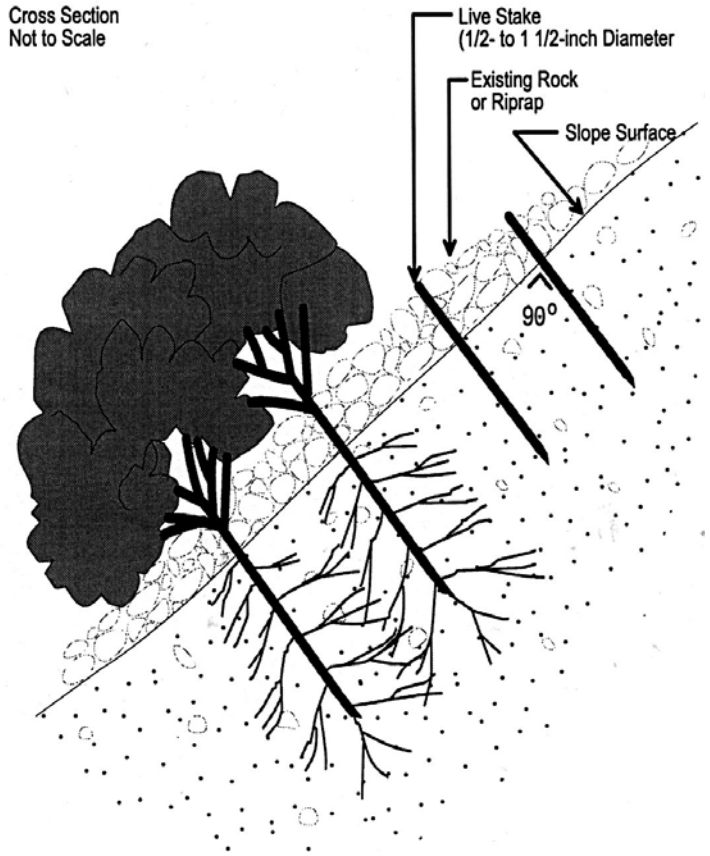


Figure 5.13 Typical Joint Planting Cross Section

Source: NRCS Engineering Field Handbook, 1992.

Tamp live branch cuttings into the openings of the rock during or after construction. The root ends should extend into the soil behind the riprap. Mechanical probes may be needed to create pilot holes for the live cuttings.

Place cuttings at right angles to the slope with growing tips protruding from the finished face of the rock.

Note: A detailed description, applications, effectiveness and construction guidelines for all types of bioengineering practices are discussed in Chapter 18, "Soil Bioengineering for Upland Slope Protection and Erosion Protection," in the Natural Resources Conservation Service's *Engineering Field Handbook*.

Erosion Control

Minimize the size of all disturbed areas and stabilize as soon as each phase of construction is complete. Seed and mulch bare areas on 3:1 or flatter slopes. Use netting, tackifiers or blankets with seeding on slopes steeper than 3:1 (see *Temporary* or *Permanent Seeding*, *Mulching* and *Erosion Control Blankets*).

Construction Verification

For woody vegetative protection alone, check that live stakes were installed according to the design specifications. For structural protection, check that cross section of the improvements, thickness of protection and live stake installation meet with the design specifications.

Troubleshooting

Consult with registered design professional if any of the following occur:

- Variations in topography on site indicate protection will not function as intended; changes in plan may be needed.
- Design specifications for vegetative or structural protection cannot be met; substitution may be required. Unapproved substitutions could result in erosion damage to the disturbed area.

Maintenance

For the first two months, check the treated area biweekly for insects, soil moisture and other conditions which could cause failure. Water or treat with insecticide, if needed.

From 4 to 6 months, check monthly and note areas where the vegetation is not growing acceptably.

Every 6 months for the first 2 years, replace dead plants with the same species and sizes as originally specified. Install during the dormant season.

Check the treated area after heavy rains or during drought. Fix gaps in the vegetative cover with structural materials or new plants. Make needed repairs to structural systems with similar material.

Protect new plantings from grazing livestock or wildlife, if needed.

After 2-year establishment period, maintenance requirements should be minimal. Heavy pruning may be required to reduce competition for light or stimulate new growth. Remove undesirable vegetation every 3 to 7 years.

Common Problems

Erosion of treated areas; caused by inadequate vegetation or improper structural protection—repair erosion, replace vegetation or structural protection and consider methods to reduce or divert surface runoff from the slope.

Slumping failure or slides in slope; caused by steep slopes—repair slide by excavating failed material, replacing vegetation and properly compacting fill. Consider flattening slope.

Sinkholes in riprap; caused by failure of the filter beneath the riprap—remove riprap, repair filter and reinstall riprap.

Death of vegetation; caused by drought or insect damage—repair and replace vegetation during dormant season, maintain biweekly or monthly inspection schedule, and water or treat with insecticide as needed.